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(54) **CEILING SYSTEM WITH INTEGRATED EQUIPMENT SUPPORT STRUCTURE**

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E04B 9/04 (2006.01)

(52) **U.S. Cl.**

CPC ***F24F 13/32*** (2013.01); ***E04B 9/006*** (2013.01); ***E04B 9/0478*** (2013.01); *F24F 2221/14* (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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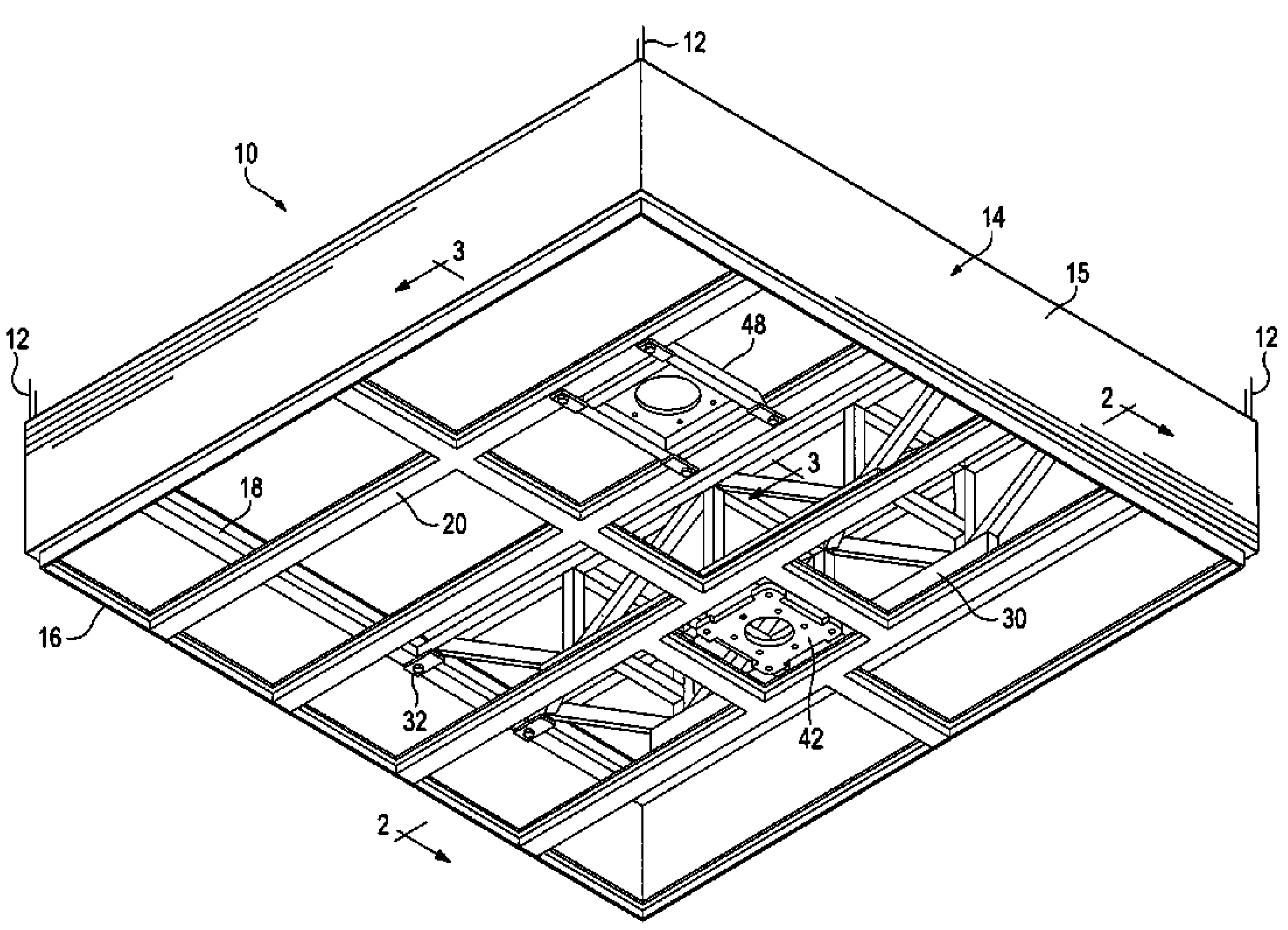
(57) **ABSTRACT**

A modular air-handling plenum for capable of supporting surgical apparatus or other objects is disclosed. The plenum is usually rectangular, may be formed of sheet metal, and features a truss spanning the width of the plenum to carry the weight of the apparatus. The plenum itself is attached to the ceiling of a room. An air handling component may be included to provide filtered and/or conditioned air in the vicinity of the suspended apparatus, or the plenum may be used strictly as an apparatus support, with no air-conditioning function. An ordinary suspended ceiling may also be mounted in the plenum for continuity with the remainder of the room.

21 Claims, 5 Drawing Sheets



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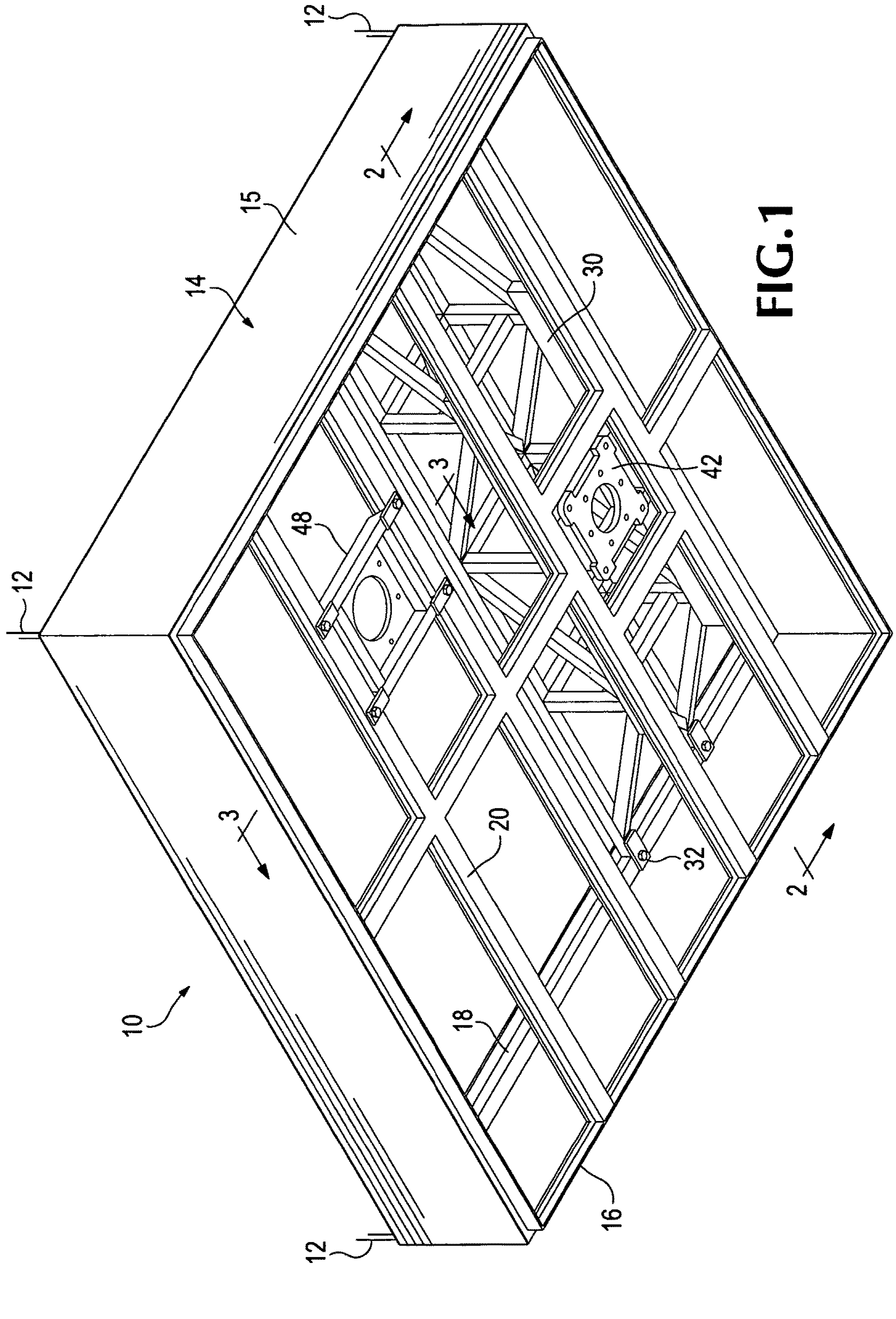

FIG.1

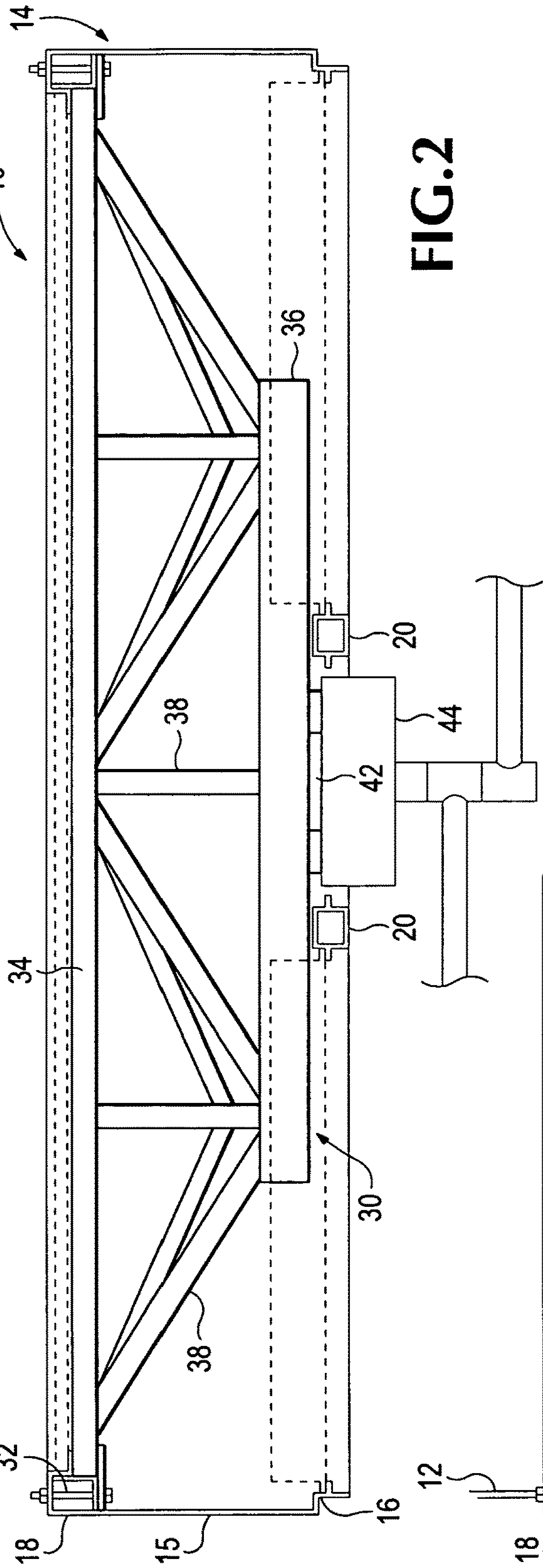
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FIG.2

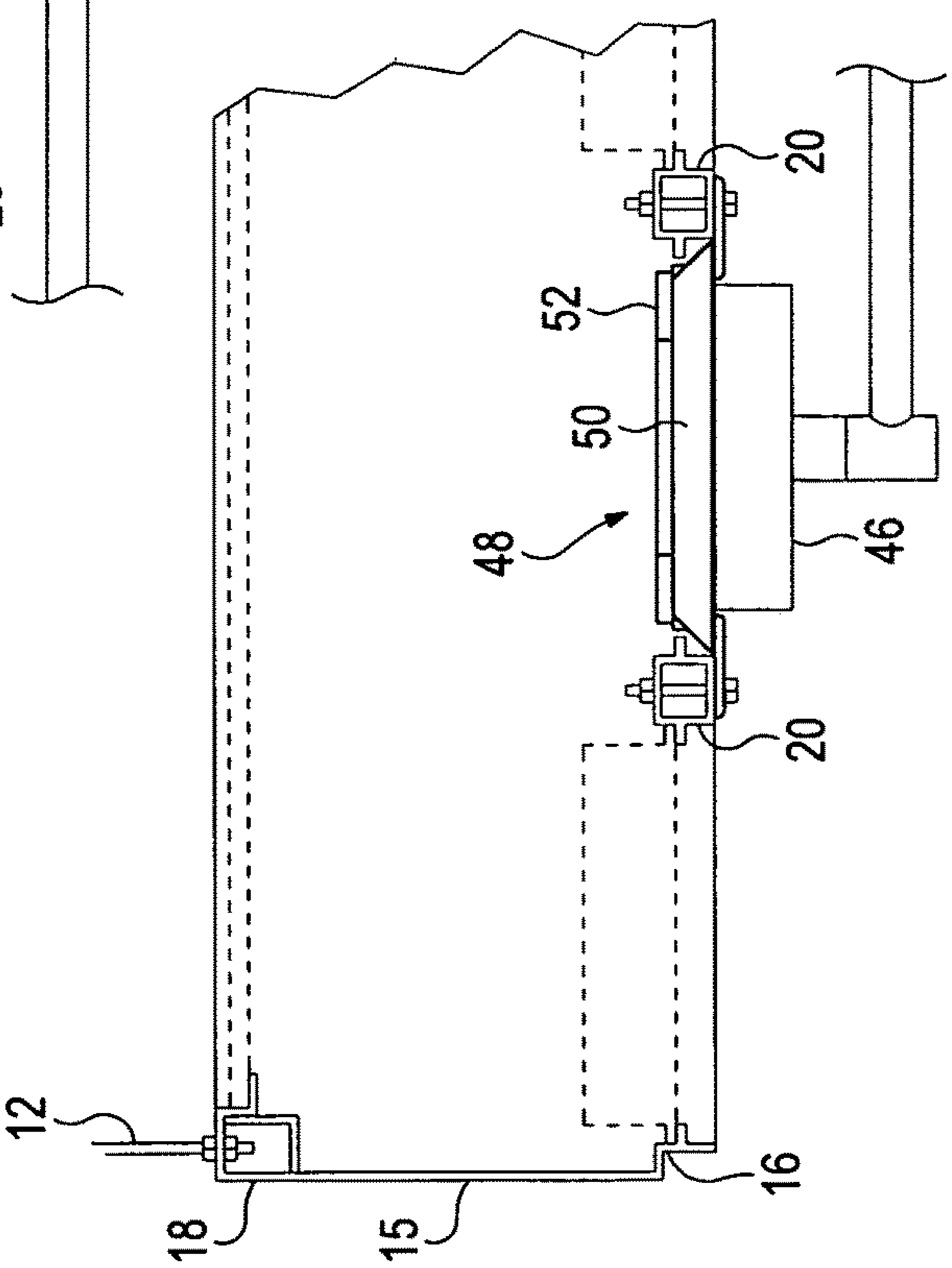
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FIG.3

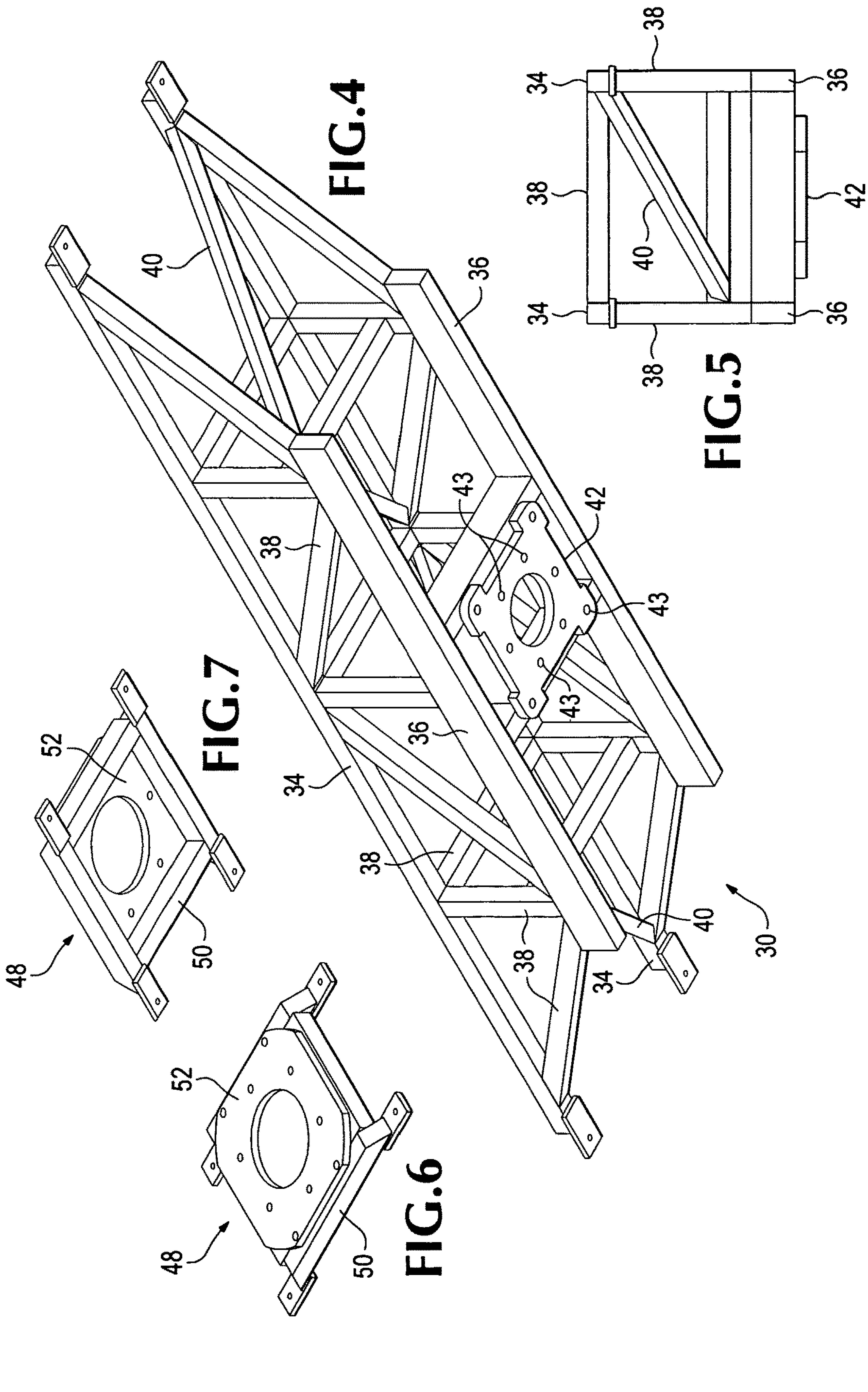

FIG.4

FIG.5

FIG.7

FIG.6

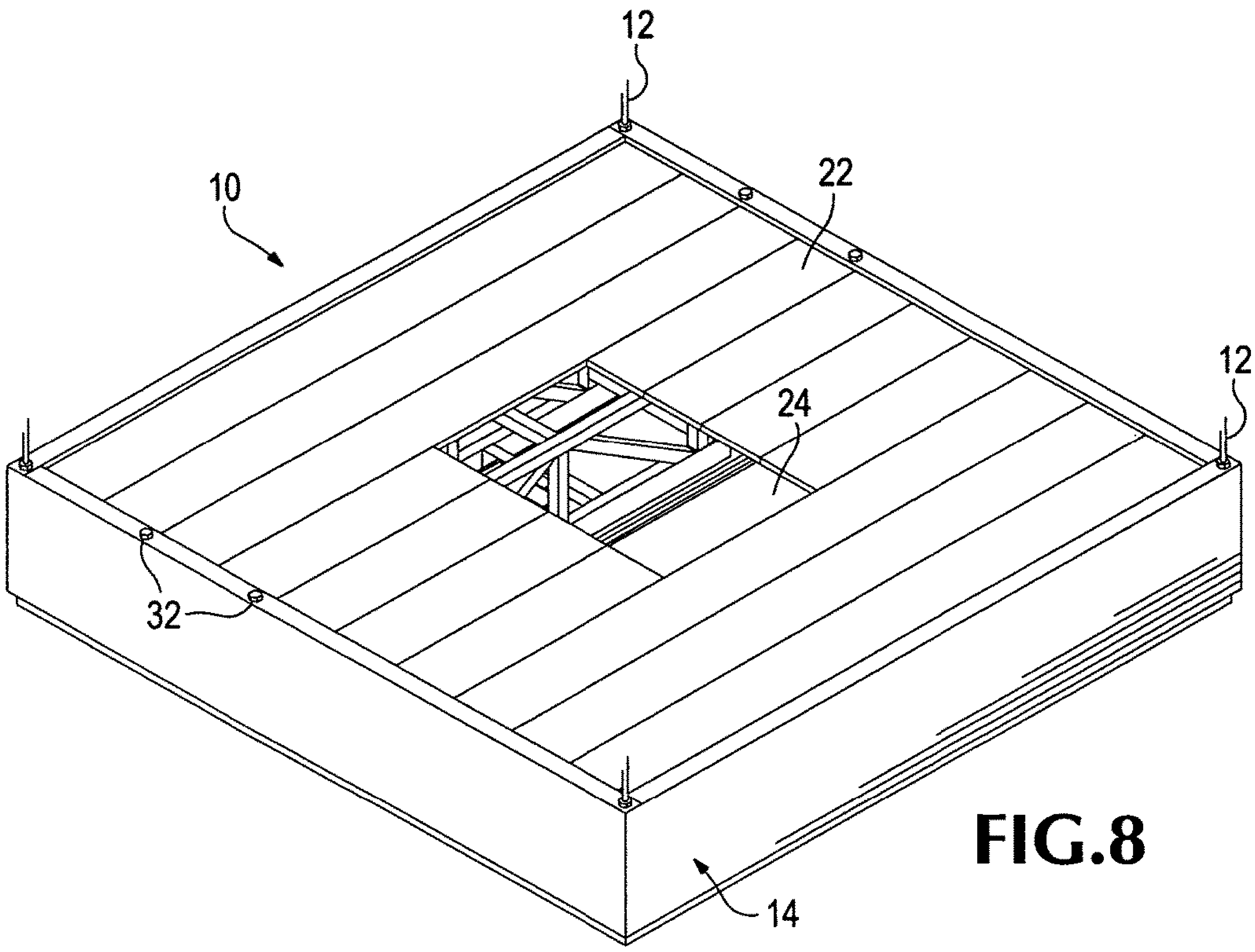

FIG.8

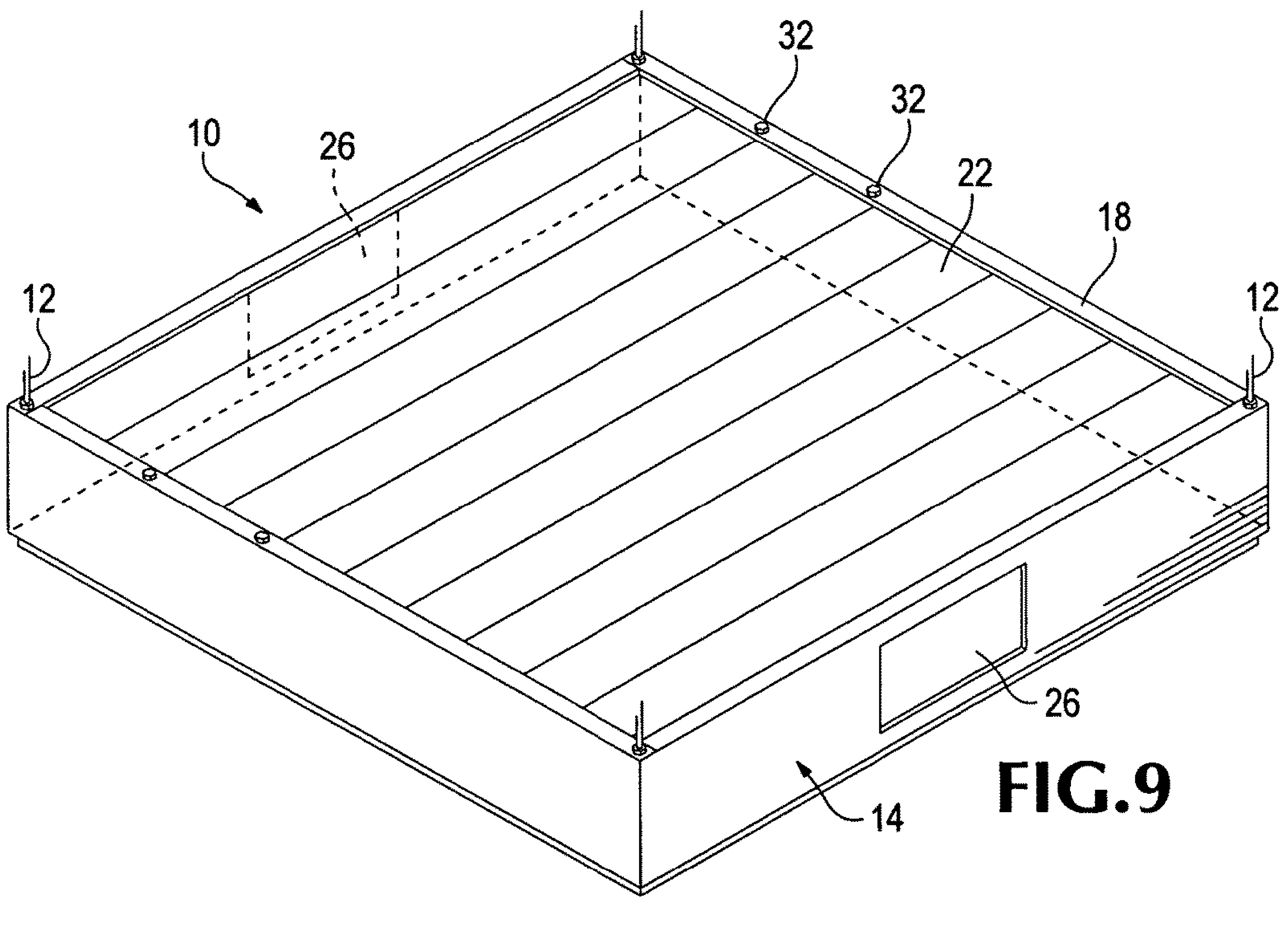

FIG.9

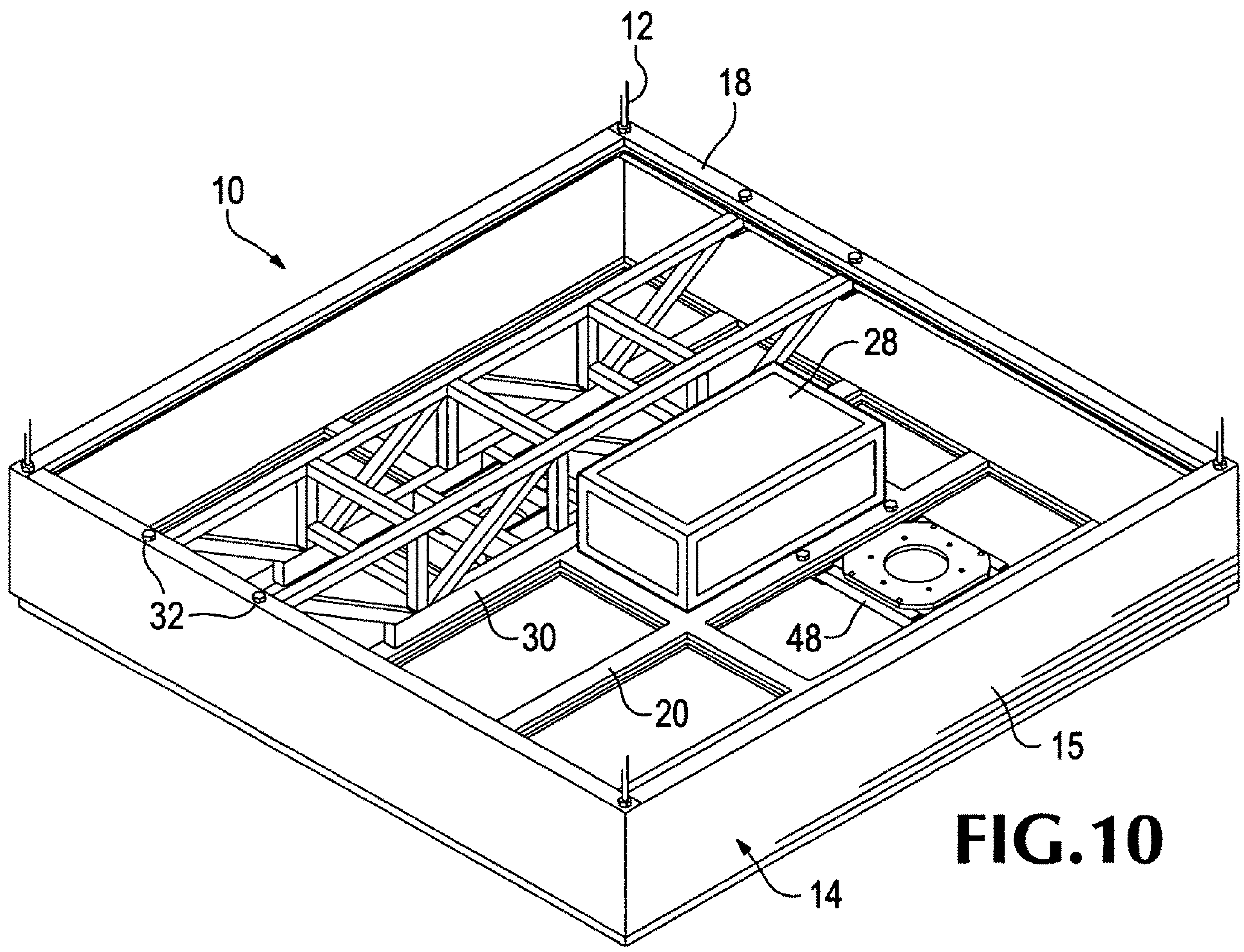

FIG.10

CEILING SYSTEM WITH INTEGRATED EQUIPMENT SUPPORT STRUCTURE

BACKGROUND

Certain interior environments, such as clean rooms and hospital like operating rooms, radiology rooms, and dental suites, require unusually clean air for the protection of the work that takes place in them. Such rooms may also have disparate heating or cooling needs at different points in the room. For instance, electronic equipment may produce excess heat, therefore requiring that cooled air be concentrated in its vicinity. Surgeons may also find it prudent to have available additional heated or cooled air in the immediate vicinity of an operating table, to hold a patient at a stable temperature or dissipate the excess heat created by bright lamps or a team of doctors and nurses surrounding the patient. However, the needs of a given room can change over time, as new technology replaces what was originally installed or the room is converted to uses or configurations other than the original. For these reasons, it is undesirable to have air conditioning and ventilation permanently installed as part of the structure of the building. Additionally, when multiple parties provide equipment for these spaces, there is significant coordination required during the design and construction phase to avoid conflicts and interferences in product and schedule. Instead, modular systems which may be installed or removed with only minor structural alterations are desirable.

Modular installation has the additional advantage of making construction less expensive and more convenient. Ventilation structures need not be custom fabricated on-site, nor incorporated into the structure during construction. Instead, modular units may be mass-produced at a factory off-site and shipped to the building when it is ready to receive them. On-site fabrication is then limited to such fabrication and alterations as are necessary to attach the modular units to the building's frame.

In modern operating rooms equipment such as robotic surgical aids are becoming more and more prevalent. These devices make surgery more precise and less prone to errors caused by the inherent fallibility of human hands. Additionally, even in more conventional clean environments, there is a significant requirement for overhead-supported equipment such as light and equipment booms, automated material handling systems, etc. Typically, such equipment is hung from the building structure and descends through the ceiling in order to preserve valuable floor space. However, this arrangement is subject to the similar problems as hard-wired ventilation: it is expensive, requires a custom installation during building construction, and may limit the possible room configurations based on the nature of the underlying building frame.

SUMMARY OF THE INVENTION

The present invention solves the problems of the prior art and permits the convenient, cost-effective, and easily alterable installation of surgical aids, or any other form of apparatus, from the ceiling of a room, including an operating or clean room. This is accomplished by providing a truss connected to a modular ventilation plenum, the truss being capable of supporting the apparatus to be hung. The truss's position within the plenum may be selected to allow some flexibility relative to the building's underlying frame, and the plenum itself, being of a modular design, may be mounted in a variety of locations. Both truss and plenum

may be assembled off-site, installed after the majority of building construction is complete, and repositioned much more easily than systems tied directly to the underlying structure. In addition, the present invention allows the convenient co-location of two items both required directly over the operating area, with neither interfering with the other: ventilation and equipment support. It also allows installation of a modular equipment support without ventilation, if preferred.

The present design also includes a suspended grid system of the type commonly found in commercial ceilings within the plenum itself, to preserve the continuity of the ceiling in the room. This grid is designed to accommodate a smaller equipment support attached to a suspended grid system, allowing the placement of smaller and lighter surgical apparatus, illumination, or similar necessities.

BRIEF DESCRIPTION OF THE SEVERAL DRAWINGS

FIG. **1** is a perspective of the plenum from below, as it would appear when installed, including the truss, suspended grid, and grid-based equipment support.

FIG. **2** is a section taken along line **2-2** of FIG. **1**, showing the truss with an appended surgical device.

FIG. **3** is a section taken along line **3-3** of FIG. **1**, showing the equipment support with an appended surgical device.

FIG. **4** is a perspective view of the truss in isolation.

FIG. **5** is an elevation view of the truss from one end.

FIG. **6** is a perspective view of the top of the equipment support, as it would appear from above the suspended grid.

FIG. **7** is a perspective view of the bottom of the equipment support, as it would appear from below the suspended grid.

FIG. **8** is a perspective view of the top of the plenum, showing a hole in the center through which air may pass as part of a ventilation system.

FIG. **9** is a perspective view of the top of the plenum, showing holes in two sides through which air may pass as part of a ventilation system.

FIG. **10** is a perspective view of the top of the plenum, showing an air handling component, such as a fan/filter unit, mounted to the suspended grid system.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Turning now to FIG. **1**, a modular unit embodying the present invention is depicted. A plenum **10** may be suspended from hangars **12**, which are in turn attached directly to the I-beams or other frame of the building. The hangars **12** may also be attached to a secondary structure (not shown) which in turn attaches to the building's frame. This arrangement permits the placement of plenum **10** in locations other than directly below the building's structural beams. Alternatively, plenum **10** may also be bolted directly to part of the building or an adapter rather than suspended from hangars **12**. Hangars **12** are shown at the corners of plenum **10**, but may be placed in other locations, or with greater spatial frequency than is shown.

The plenum **10** is formed from a perimeter **14** of material, conventionally sheet steel although any sufficiently rigid material will do, using methods well known in the art. The plenum **10** is typically a rectangle or square, and is built in a size chosen to accommodate the heating and cooling needs of the building as well as to accommodate the structure to which it is to be attached. The perimeter **14** is given enhanced rigidity by the presence of lower lip **16** and upper rail **18**. The upper rail **18** provides the primary structural member of the plenum **10**. The rail is typically constructed of steel 0.188 inches thick, formed into a rectangular tube about 3"×4". The upper rail **18** is welded to sheet steel wall **15**, and lower rail **16** is formed by bending wall **15**. Grid members **20** may be attached to lower lip **16**, forming a grid of supports for the ordinary parts of a suspended ceiling, such as ceiling tiles, lights, and vents for air passage (not shown). Alternatively, grid members may be attached to the sheet steel wall **15** directly. Grid members **20** are conventionally constructed as rectangular tubes or U-shaped channels of stainless steel, or extruded aluminum, but may be constructed of other materials and in other shapes as well. The grid members **20** are sufficiently rigid that that they span the plenum **10** without additional support, easing attachment of the plenum **10** to the building structure and installation of the grid members **20**. Grid members **20** may also be attached to the building structure, for instance by the use of additional hangars **12**, for greater load-bearing capacity.

The plenum **10** may be sealed at the top to control airflow by plenum roof **22**, best shown in FIGS. **8** and **9**. This roof is usually sheet metal similar to that found in perimeter **14**, but need not be. A hole **24** may appear in the plenum roof **22** to permit air to enter or leave the plenum **10**, and therefore the room, or holes **26** may be found in perimeter **14** for the same purpose. An air handling component (not shown) may be mounted adjacent holes **24** or **26**, or a duct (not show) may lead to them. Alternatively, the plenum may have an air handling component **28** mounted directly to the grid members **20**, as best shown in FIG. **10**, such that the plenum itself does not control airflow. The air handling component may comprise a fan, a filter, air conditioning coils, heating elements, humidifiers, dehumidifiers, or any combination of these or similar elements, all of which are well known in the art.

A truss **30**, best shown in FIGS. **2** and **4**, spans the plenum **10** and is firmly attached to the upper rail **18**. In a rectangular plenum **10**, the truss **30** preferably spans the shorter dimension, so as to maximize its weight-bearing capacity. In the figures, truss **30** is attached by bolts **32**, which allows for easy installation and removal. Any other suitably rigid form of attachment, such as rivets or welding, may be used, although these may not be as convenient. The truss **30** is composed of upper spars **34**, lower spars **36**, and various cross members **38**, which link the spars together and provide rigidity. Diagonal cross members **40** provide resistance to twisting. The truss **30** may be constructed of steel or aluminum that has been cast, extruded, forged, or otherwise formed into structural shapes, such as tubes, I-beams, or U-channels. The truss **30** may also be made of composite materials such as fiberglass or carbon fiber, formed sheet steel, or any other suitably sturdy material. The truss **30** may even employ several different types of material in its construction. The spars **34**, **36** and cross members **38**, **40** are preferably welded together if metal, and glued or molded as a single piece if composite, but they may also be joined by bolts, rivets, or other means known in the art. The precise choice of materials and design for the truss **30** will be determined by such factors as the required strength, the need to minimize weight, and the manufacturing cost. These considerations are well understood in the art. It will be understood that no particular configuration of spars and cross members, nor any particular material choice, is required to practice the spirit of the invention.

The truss **30** may also be installed as part of the perimeter **14** of a plenum, or even between two neighboring plenums **10**, forming a part of the perimeter **14** of each. In this configuration, the truss **30** may be open to airflow. The truss **30** may also be closed to airflow, for instance by attachment of a sheet of metal across one or both sides of the truss **30**.

The truss **30** may incorporate dedicated passageways for routing of electrical conduits or lines supplying such things as natural gas, refrigerant, water, gases such as oxygen or nitrogen, or vacuum.

An equipment interface plate **42** is mounted to the truss **30** between the lower spars, and provides a mounting location for heavy equipment **44**, such as robotic surgical aids. This plate is most commonly metal, but may be any material of suitable strength. Preferably, the equipment interface plate **42** has a bolt-hole pattern **43** which matches that of heavy equipment **44** to permit convenient installation and removal without the need for adapters or jigs. The holes may be threaded or clearance holes. The equipment interface plate **42** may be welded to truss **30**, or bolted for easier installation and removal. Other attachment methods, such as riveting, are also possible. It may be manufactured "blank," without any bolt-hole pattern **43**, and then machined to match whatever heavy equipment **44** is ultimately selected.

The weight of the heavy equipment **44** is transferred by the truss **30** to the upper rail **18** (and to some degree, to the remainder of perimeter **14**), and thence to the hangars **12** and into the building's structure. The truss **30** may be independent of the grid members **20**, so that any movement in the truss **30** is not directly transferred to the grid members **20**, and vice versa. This may be advantageous when, for instance, a light (not shown) attached to grid members **20** is manually adjusted; the movement of the light will have a minimal effect on the heavy equipment **44** suspended from the truss **30**. When the truss **30** and grid members **20** are structurally independent, they may be loaded independently of each other, with reference only to the total load that the plenum **10** and hangars **12** can support. On the other hand, the truss **30** and grid members **20** may be linked together. This configuration provides maximum load-bearing capacity and maximum lateral stability for the heavy equipment **44** mounted on the truss **30**.

The truss **30** shown in the drawings, when constructed out of welded tube steel and connected to the plenum **10**, can support at least 900 lbs of heavy equipment **44** and can bear at least 8000 ft-lbs of torque about an axis running parallel to the spars **34**, **36**.

Lighter apparatus **46** may also be attached to the plenum **10** at the grid members **20**, either on the top or bottom of these members, by the use of apparatus mount **48**. The grid members are obviously not capable of supporting the same amount of weight as the truss **30** due to their flatter construction, and in addition, they must bear the weight of multiple other items, such as lighting. However, apparatus mount **48** is also more versatile than truss **30**. It allows the positioning of lighter apparatus **46** in more places, including some not reachable by truss **30**, and also permits the repositioning of lighter apparatus **46** much more conveniently. Similar to the operation of truss **30**, apparatus mount **48** transfers the weight of lighter apparatus **46** to the grid members **20**, which then transfer it to the lower rail **16**, then through perimeter **14** and into hangars **12**. When used unreinforced, the grid can bear around 300 lbs. in weight. This amount may be raised considerably by hanging a stud **12** from the building's structure and attaching it to the grid members **20** directly for additional support.

Apparatus mount **48** is comprised of frame **50** and support plate **52**. As with the other components of the plenum **10**, these advantages are best achieved if apparatus mount **48** is bolted to the grid members **20**, but it may also be attached in other ways. Similar to equipment interface plate **42**, the support plate **52** may be welded to frame **50**, but it may also be bolted, riveted, or otherwise attached.

It is also possible for the plenum to be installed with no air-conditioning function at all, purely as a hanger for ceiling-mounted equipment. In that case, the truss **30** or apparatus mount **48** can be mounted within the plenum **10**, but without any air-handling component **28**, plenum roof **22**, or holes **26**. This system is modular, convenient, and inexpensive, and may be employed anywhere, whether in a clean room, operating room, or ordinary office or industrial environment that requires equipment to be hung from above.

What is claimed is:

1. A modular unit configured for attachment to a building frame, the modular unit comprising:
- a plenum having walls defining a perimeter of material;
- a horizontal rail extending along a top of the plenum and connected to and supporting each of the walls of the plenum, the rail connected to an upper portion of each wall;
- a grid of supports attached to the plenum, the supports defining a suspended ceiling; and
- a truss separate from the grid of supports and directly attached to and supported by the rail, the truss arranged inside the plenum, the truss configured to support ceiling-mounted equipment and transmit the load of the ceiling-mounted equipment to the rail,

wherein the plenum is suspended from the building frame.

2. The modular unit of claim **1** wherein the plenum is suspended from the building frame by a plurality of hangers.

3. The modular unit of claim **1** wherein the truss includes an equipment interface plate configured to attach to the ceiling-mounted equipment.

4. The modular unit of claim **1** including an apparatus mount which is attachable to the grid of supports, wherein the ceiling-mounted equipment is configured to be hung from the apparatus mount.

5. The modular unit of claim **1** wherein the truss is attached to the grid of supports.

6. The modular unit of claim **1** wherein an air handling component is positioned within the perimeter.

7. The modular unit of claim **1** further comprising a top attached to a top margin of the perimeter along the entire perimeter, forming a substantially airtight seal therewith.

8. The modular unit of claim **7** wherein the perimeter has at least one side and a hole formed through the at least one side, wherein the hole is configured to permit air to flow into the unit.

9. The modular unit of claim **8** wherein an air handling component is positioned proximate the hole.

10. The modular unit of claim **7** wherein the top has a hole configured to permit air to flow into the unit.

11. The modular unit of claim **1**, wherein the truss comprises at least one upper spar connected to at least one lower spar by at least one cross member.

12. The modular unit of claim **11**, wherein the truss further comprises at least one diagonal cross member configured to provide resistance to twisting.

13. The modular unit of claim **1**, wherein the truss includes at least one dedicated passageway configured for routing of electrical conduits or supplying natural gas, refrigerant, water, or gas.

14. The modular unit of claim **1**, wherein the grid of supports is attached to a lower portion of the walls of the plenum.

15. A modular unit configured for attachment to a building frame, the modular unit comprising:
- a plenum having a perimeter of material formed into a rectangular box;
- a horizontal rail extending along a top of the plenum and connected to and supporting the plenum;
- a grid of supports attached to the perimeter of the plenum, the supports defining a suspended ceiling suspended from the perimeter of the plenum;
- a truss separate from the grid of supports and directly attached to and supported by the rail, the truss contained inside the rectangular box; and
- an apparatus mount attached to at least one of the supports, wherein an apparatus is configured to be hung from the apparatus mount,

wherein the plenum is suspended from the building frame.

16. The modular unit of claim **15** wherein the grid of supports is attached to a bottom margin of the perimeter.

17. The modular unit of claim **15** wherein the grid of supports comprises extruded aluminum.

18. The modular unit of claim **15** wherein the grid of supports comprises sheet steel formed into a tubular configuration.

19. The modular unit of claim **15** wherein the grid of supports comprises sheet steel formed into an inverted U-channel configuration.

20. The modular unit of claim **15** wherein the apparatus mount includes a support plate configured to rigidly attach to the apparatus.

21. A modular unit configured for attachment to a building frame, the modular unit comprising:
- a plenum having walls defining a perimeter of material;
- a horizontal rail extending along a top of the plenum and connected to and supporting each of the walls of the plenum, the rail connected to an upper portion of each wall;
- a grid of supports attached to the plenum, the supports defining a suspended ceiling;
- a truss separate from the grid of supports and directly attached to and supported by the rail, the truss arranged inside the plenum, the truss capable of supporting at least 900 lbs of ceiling-mounted equipment and transmitting the load of the ceiling-mounted equipment to the rail, and wherein the plenum is suspended from the building frame by a plurality of hangers.

* * * * *